An experimental investigation into the transmission of antivax attitudes using a fictional health controversy.

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Abstract

Rationale. Although vaccines are an invaluable weapon in combating diseases, they are often surrounded by controversy. Vaccine controversies usually arise with the claims of some parents or doctors who link vaccines to harmful outcomes. These controversies often negatively affect vaccination coverage.

Objectives. This experiment simulated a vaccine controversy to understand which content features of vaccination-related information are well transmitted and how this transmission affects vaccine intention.

Method. All participants (*N*=64) read two conflicting views (pro- and anti-) about a fictional vaccine ('dipherpox vaccine'). These conflicting views were held by a parent and a doctor, whose views varied across conditions. This information was transmitted along linear chains of four participants who recalled it and the product of their recall was passed to the next participant within their chain. They also responded whether they would vaccinate or not.

Results. The experience-based view held by the parent was better transmitted than the medical-based view held by the doctor, while the pro-vaccine and anti-vaccine views were similarly transmitted. Despite all the participants having neutral or positive attitudes towards vaccines in general, 39.1% of them decided not to vaccinate. Nevertheless, vaccination attitude was the strongest predictor of vaccination intention. The less positive participants' attitudes were towards vaccines in general, the less likely they were to vaccinate against dipherpox after exposure to the controversy.

Conclusion. The results suggest that vaccination campaigns may be made more effective by including personal experiences of the negative consequences of non-vaccination.

Keywords: Vaccine Controversy; Vaccination Attitudes; Vaccine Hesitance; Cultural Evolution; Cognitive Biases; Emotional Bias; Omission Bias; Post-Truth

Introduction

Vaccination is an invaluable weapon in combatting diseases. Vaccines prevent 26 infectious diseases (CDC, 2015) and the deaths of around two and a half million people per year (WHO, 2016). However, vaccinations are often surrounded by controversy. These controversies usually arise with claims that link specific vaccines with negative outcomes such as brain damage or autism (Baker, 2003; Offit, 2008). The spread of these claims reduces vaccination intention and erodes herd immunity, which makes disease outbreaks more likely to occur. Globally, anti-vaccination attitudes have overtaken vaccine access as the primary barrier to vaccination (Larson et al., 2016). Consequently, it is vital to understand how vaccination-related information is transmitted and how this can influence vaccination intention.

To better understand how negative attitudes toward vaccinations spread, we utilize approaches from cultural evolution (Mesoudi, 2011). Research in this area suggests that the distribution and stability of socially learned information is affected by *content transmission biases*, which favour certain types of information over others (Stubbersfield, Flynn, & Tehrani, 2017). For instance, emotional (Eriksson & Coultas, 2014; Stubbersfield, Tehrani, & Flynn, 2017) and negative information (Bebbington, MacLeod, Ellison, & Fay, 2017) have a transmission advantage over non-emotional (*emotional content bias*) and positive information (*negative content bias*) respectively. The exploitation of these biases by anti-vaccination groups (e.g. Bean, 2011) might partly explain the popularity of anti-vaccination messages on the Internet (e.g. Tomeny, Vargo, & El-Toukhy, 2017) and the higher perception of risks and lower vaccination intention after exposure to these websites (Betsch, Renkewitz, Betsch, & Ulshöfer, 2010).

Omission bias, i.e., a tendency to consider the negative outcomes resulting from an action (commission) as worse than the same negative outcomes resulting from a lack of action (omission), might also affect the differential transmissibility of pro-vaccination and anti-vaccination messages (*omission content bias*). Many people prefer not to vaccinate when the probability of having symptoms of a vaccine-preventable disease are equal or higher than the probability of suffering from vaccine side effects (e.g. DiBonaventura & Chapman, 2008; Ritov & Baron, 1990; Wroe, Turner, & Salkovskis, 2004).

Another class of transmission biases are *model-based biases.* These biases increase the probability of adoption of behaviours and attitudes that are displayed by certain individuals such as prestigious or self-similar individuals (Henrich, 2016). The most common sources of vaccine-related information are doctors and parents. Doctors are considered the most trust-worthy source of vaccine-related information (Freed, Clark, Butchart, Singer, & Davis, 2011). This high level of trust might be explained by their prestige and medical expertise. Although doctors generally support vaccinations, they can also emphasize concerns about vaccine safety (e.g. Manca, 2018). The interaction between the prestige model-based bias with omission and negative content biases makes the negative messages about vaccines transmitted by these professionals especially likely to spread, influencing public opinion and vaccination coverage.

Parents who believe vaccines have harmed their children are also frequently represented in the media. Although these parents are less trusted (Freed et al., 2011), a qualitative study showed that parents considered the testimony of other parents who believed that the MMR vaccine caused their child's autism to be especially reliable (Hilton, Petticrew, & Hunt, 2007). This might be because parents are thought not to have hidden interests, while doctors, governments, and pharmaceutical companies often feature in medical conspiracy theories.

Aims and Hypotheses

The first aim was to study which content features of vaccination-related information are well transmitted. To this end, the method of serial reproduction (Bartlett, 1932) was used to experimentally simulate a vaccine controversy. This method is similar to the children's game

"Chinese Whispers" (also known as "Telephone") and entails the transmission of information along linear chains of participants. The first participant within each chain (First Generation) receives the original information and recalls it later. The product of their recall is transmitted to the next participant in their chain (Second Generation), who recalls this information and their recall is transmitted to the next participant in their chain (Third Generation). This process is repeated by a number of generations. This method permits both quantitative analyses of the cumulative recall of the information (Mesoudi, 2007) and qualitative analyses of the transformations introduced by the participants during transmission (Bartlett, 1932).

For the purposes of our experiment, we created a false balance magazine-like article (Dixon & Clarke, 2013), in which two opposed views (pro-vaccine, anti-vaccine) were presented as having equal weight (Supplementary Material 1A). In line with the *omission content bias*, we predicted that:

> H1: Information that emphasizes the vaccine risks (anti-vaccination view) will be better transmitted across generations than the information that emphasizes the risks of the vaccine-preventable disease (pro-vaccination view).

Moreover, these opposing views were held by a parent ('Mr. Bill Symons') and a doctor ('Dr. Chloe Williams'). In Condition 1, the doctor was in favour of the vaccine from a medical perspective (e.g., "the vaccination program has been very successful … 95% of the population has been vaccinated, which … makes a[n] … outbreak highly unlikely") and the parent was against the vaccine from an experience-based perspective, which adopted an emotional tone (e.g., "My … baby had never produced such a blood-curdling scream as he did at the moment the shot was given. Two hours later…, … [H]e was unable to breathe"). In Condition 2, the doctor was against the vaccine from a medical perspective (e.g., "the vaccination program has had some worrying results…95% of the population has been vaccinated, which makes a portion of the population highly likely to suffer from the vaccine side effects") and the parent in favour of the vaccine from an experience-based perspective, which also adopted an emotional tone (e.g., "My … baby had never produced such a blood-curdling scream as he did the day he got [the disease] ... [H]e was unable to breathe]"). In line with the *emotional content bias*, we predicted that:

> H2: The parent's experience-based view will be better transmitted across generations than the doctor's expertise-based view.

H3 followed from H1 and H2:

> H3: The transmission advantage of the anti-vaccine view will be more marked when this view is provided by the parent than when it is provided by the doctor.

A second aim of the experiment was to study how the transmission of information affects people's willingness to vaccinate or not. We predicted that, if the anti-vaccination view has a transmissibility advantage and becomes more dominant over generations (H1) then,

> H4: People's willingness to vaccinate will decrease over generations.

Methods

Ethics Statement

The study was approved by the Department of Anthropology Ethics Committee at Durham University on 24th June 2016.

Participants

64 English-speaking (43 British, 21 Americans) Prolific (www.prolific.ac) participants (37 males, 27 females) aged 18-61 (*M*=32.87, *SD*=11.08), all with neutral or positive attitudes towards vaccination, were included in the study. Participants with negative attitudes towards vaccines were identified through the use of two items to measure vaccination attitudes

(Materials, Design and Procedure). See Supplementary Material 1B for details about inclusion and exclusion criteria and the recruitment procedure.

Materials, Design and Procedure

An article about the dipherpox vaccine (the disease and vaccine were invented for the purposes of the experiment) was used as material to transmit along the chains. See Aims and Hypotheses for details about experimental conditions and Supplementary Material 1C for counterbalancing.

At the beginning of the experiment, participants were randomly assigned to one of the 16 four-participant/generation transmission chains (eight chains per condition). They were instructed to carefully read an article, which was either the original material (First Generation) or the information recalled by a previous participant within each chain (Second to Fourth Generations). Spelling mistakes were corrected before transmitting the information from one participant to the next. Afterwards, participants provided their demographic details. Then, all of them completed a surprise recall test, in which they were instructed to recall the previously presented article as accurately as possible. Participants in the first to third generations had between five and ten minutes to submit their response. Because participants in the last generation received a considerably smaller amount of information to read and recall, they were given the possibility to submit the information after three minutes. Later, participants were asked whether, taking only into account the provided information, they would be willing to vaccinate or not. They were also given the opportunity to express their opinion. Lastly, they were asked about their general attitudes towards vaccination using two items: "*If I had a baby to care for, I would want him/her to get all the recommended immunizations*" and "*I believe that scheduled immunizations are safe for children*" (Browne, Thomson, Rockloff, & Pennycook, 2015). A 7-point Likert scale was used to collect the participants' responses

(1=totally disagree, 7=totally agree). The scores of these two items were summed together and converted into a single scale (Cronbach's α=0.82).

Because participants received as input the recall of participants who occupied a previous position in their chain, the outputs (i.e., recall of the text) of participants in the same chains did not represent independent data points. In addition, the transformations introduced by previous participants in a chain were assumed to influence the willingness of later participants to vaccinate. Consequently, multilevel modelling with the lme4 package (Bates, Maechler, Bolker, & Walker, 2015) in R-3.4.0 (R Core Team, 2017) was used (Supplementary Material 2).

Coding

For assessing participants' recall accuracy, 22 central propositions per source (parent/doctor) in each condition were considered (Supplementary Materials 1D-E). As in previous transmission chain studies using text, 'proposition' here refers to a predicate (a verb, adjective, or other relational term) followed by ordered arguments (the complementary noun/s). 'Central propositions' refers to propositions which are central to the narrative (Stubbersfield, Tehrani, & Flynn, 2014). Before the experiment was conducted, a table with the criteria to score the recall accuracy of each proposition was created (Supplementary Material 3). A second coder who was blind to the hypotheses coded two full chains (12.5% of the material). There was a high correlation ($r(14)=0.9$) between the recall counts given by the first (Supplementary Material 1F) and second coder (Supplementary Material 1G).

Results

Cumulative Recall

Multilevel Poisson regression models were generated to measure which model had a better fit with the data (Supplementary Material 1H). A lower Akaike's Information Criterion (AIC) by a difference of two or larger is considered evidence of better fit to the data. A control model with generation as fixed effect and chain as a random effect (AIC=576) was used to compare its fit with the remaining models.

To test H1, which stated that the anti-vaccination view would be better transmitted than the pro-vaccination view, two models were produced. A model with generation and view as fixed factors (AIC=577) had a similar fit to the control model (AIC=576). Allowing the interaction between generation and view was detrimental to the model fit (AIC=579). The results, therefore, do not support H1 (Figure 1).

To test H2, which stated that the experiential-based view of the parent would be better transmitted than the information provided by the doctor, two models were produced. A model with the source of the information and generation as fixed effects had a better fit (AIC=566) than the control model. Allowing the interaction between source and generation improved the fit of the model (AIC=562). While there were no differences between both sources of information in the generation 1 (β=-0.04, *SE*=0.13), the advantage of the information provided by the parent was clear in generation 2 (β=0.46, *SE*=0.21) and increased further by generation 4 (β=0.68, *SE*=0.26). These results support H2 (Figure 1).

To test H3, which stated that a negative experience-based view from the parent would be better transmitted than a negative expertise-based view from the doctor, a model that included the interaction between condition and view was conducted (AIC=569). Although the fit of this model was better than the control model and the view model, it had a worse fit than the source models. Figure 2 shows the effects of the transmission of information across experimental conditions. Whereas the parent's anti-vaccination view is clearly better transmitted than the doctor's pro-vaccination view in Condition 1, the parent's pro-vaccination view and the doctor's anti-vaccination view were similarly transmitted in Condition 2.

The inclusion of demographic variables and vaccination attitudes in the models did not improve the model fit (Supplementary Material 1H).

Narrative Evolution

The gist of the article (the reference to two opposing views about the dipherpox vaccine) was very well transmitted across generations. The gist was maintained until the fourth generation in ten out of 16 chains (62.5%). Moreover, four of the remaining chains conserved the related idea that the vaccine had pros and cons (25%). In two chains only either the pro-vaccination (6%) or the anti-vaccination (6%) message survived (Supplementary Material 4A). This might have influenced decisions, as 100% and 75% participants in these chains decided to vaccinate or not to vaccinate respectively (Supplementary Material 4B).

Both sources of information (parent and doctor) were conserved in ten chains until the fourth generation (62.5%). Three chains conserved only the parent as the source of information (18.75%), and in one of these chains none of the information provided by the doctor was preserved. Another three chains did not conserve any reference to the sources (18.75%, Supplementary Material 4C). The gender of the parent (male) was well transmitted across generations (Supplementary Material 4D). In 11 chains (68.75%), his gender was transmitted until the fourth generation. In contrast, the gender of the doctor (female) was not well transmitted across generations (Supplementary Material 4E). Only five chains conserved the gender of the doctor in the first generation (31.25%) and only one of the chains conserved the gender of the doctor until the fourth generation (6.25%).

The process of transmission led to some distortions and the emergence of novel content. In one chain, the 95% vaccination rate became a “95% success rate” before being distorted into “around 5% of babies” showing “alarming side effects”, which included “brain swelling, bleeding and other abnormalities”.

Vaccine Decisions

Among the participants, 39.1% were not willing to vaccinate against dipherpox. To study which variables predicted their decision, a logistic fixed intercept model (AIC=87.6) was first compared with a logistic random intercept model with chain as a random effect (AIC=89.4). As the model fit of both models was similar, the following models adopted a single level structure.

To test H4, which stated that participants' willingness to vaccinate would decrease over generations, a generation-only model (AIC=91.9) was produced. Contrary to H4, generation did not predict the decision to vaccinate. An exploratory full model including generation, demographic variables (age, gender and nationality), condition, attitudes towards vaccines, and the ratio of number of pro-vaccination propositions to the total number of propositions correctly recalled improved the model fit of the null model (AIC =73). This was due to the effects of three variables (attitudes towards vaccines, age, and the ratio of pro-vaccination to anti-vaccination propositions correctly recalled). A model with only these variables further improved the model fit (AIC=66.1). In this model, attitudes towards vaccines was the strongest predictor, which indicated that the more positive participants' attitudes towards vaccination, the more likely they decided to vaccinate (β=2.77, *SE*=0.78). Age was negatively related to the decision to vaccinate (β=-1.53, *SE*=0.69), while the ratio of pro-vaccination propositions to total number of propositions correctly recalled was positively related to the decisions to vaccinate (β=1.28, *SE*=0.67). See Supplementary Material 1I. Figure 3 shows the relationship between pro-vaccination attitudes and decision to vaccinate across experimental conditions.

Participants' explanations

Among the participants, 31 provided an explanation for their decision (Supplementary Material 1J). Participants' decisions were mainly based on weighing the risks and benefits of the vaccine (58%, e.g., "the disease doesn't seem severe enough to risk an adverse reaction to the vaccine" or "I think it is worth the risk to have the vaccine to prevent catching the virus").

The source of information was also used as argument (29%). When provided by the doctor, the anti-vaccine view convinced six participants not to have their child vaccinated (e.g., “I feel a little safer going with the opinion of the Doctor as he may not be as biased as a father when it involves his own children”). Two participants based their decision to vaccinate on the doctor’s opinion (e.g., “if the doctors say it is worth it despite [scary side effects], I would probably not want to take the chance of being un-vaccinated”). Another two participants discredited the doctor’s opinion (e.g., "vaccination is a serious issue, we should be careful when citing a doctor because some of them have agendas to fulfill”) or gave more relevance to the parent’s account (e.g., "the father's comments were very relevant to me as the mother of a young child, and I would weigh the risks of the disease more heavily than that of the vaccination”). Among the participants, 32% wanted more information to make their decision (e.g., "I would … look for opinions of other medical professionals”), including statistics (e.g., “whilst I support vaccination … the lack of statistics in the article makes me wary”).

Discussion

Contrary to H1, we did not find support for the omission bias: the anti-vaccination view was not better transmitted than the pro-vaccination view. In contrast, we did find support for H2: the parent’s experience-based account was better transmitted than the doctor’s expertise-based account. One plausible explanation is that the experiential account had a strong emotional component (emotional bias). The doctor’s account was considerably less emotional and gave more emphasis to “hard facts”, which were probably less able to engage participants’ interest and attention. Consequently, vaccination campaigns may be made more effective by including personal experiences of the negative consequences of non-vaccination.

Despite all the participants having neutral or positive attitudes towards vaccines in general, 39.1% of them decided not to vaccinate. The strongest predictor was vaccination attitudes. The less positive participants’ attitudes were towards vaccines in general, the less likely they were to vaccinate against dipherpox after exposure to the controversy. Importantly, the existence of two opposing views about the vaccine was remarkably well conserved along the chains. This suggests that being exposed to vaccine controversies makes people with neutral or slightly positive attitudes towards vaccination less likely to vaccinate. Therefore, the efficacy of vaccination campaigns might benefit from targeting “fence-sitters” (Leask, 2011).

Previous research has shown that falsely balanced articles have a greater influence than exposure to only one side of vaccine decisions (Dixon & Clarke, 2013). In this study, however, the ratio of correctly recalled pro-vaccination to total recalled propositions positively predicted the decision to vaccinate. Thus, the salience of the pro-vaccination and anti-vaccination information available in an article or memory might also influence vaccine decisions.

Limitations

The study does not allow the disentanglement of the effects of the style of the presentation of the information (experiential vs expertise) on cumulative recall from the effects of the source of the information (parent vs doctor). Nevertheless, the attribution of the experience-based perspective to the parent and the expertise-based perspective to the doctor gave realism to the controversy. Moreover, the gender of both sources was contrary to stereotypes. The data shows that the gender of the doctor (female) was poorly transmitted but the gender of the parent (male) was well transmitted. Therefore, the transmission advantage of the information provided by the parent might be due to a salience effect related to the gender of the source and cultural gender stereotypes (i.e., reading about a father concerned about his child’s health might have caused surprise, as this is stereotypically associated with mothers). However, the preservation of the parent’s gender was due to the use of a gender-specific word (father), while a gender-neutral word was used for the female source (doctor). Moreover, even if the results for the transmission of information were caused by surprise, it still supports the idea that the most emotive text was more successful in transmission. Another limitation was the small (*N*=64) sample size.

Conclusions and Directions for New Research

While the results of the cumulative recall do not support an expertise-based prestige bias and suggest an advantage for more emotive information over statistical information, the qualitative analysis of the reasons participants gave for their vaccination decision suggests that in decision making such aspects could be important. Participants gave reasons alluding to greater trust of the expertise-based source and suggested they would need more statistical information before choosing to vaccinate.

This study suggests several possibilities for future research into the transmission of vaccination-related information and anti-vaccination attitudes. First, further study is necessary to establish how important the style of presentation (experiential vs expertise) is compared to the source of information (parent vs doctor). Second, future research must look at the effects of the gender (stereotypical consistent vs stereotypical inconsistent) of the sources. Third, more studies need to focus on how the salience of pro-vaccination and anti-vaccination information influences vaccination intention. Fourth, studies with larger sample sizes are necessary to increase confidence in the results. Lastly, future research should examine which types of information (and sources of information) are salient in memory, and therefore likely to be successful in cultural transmission, and which types are salient in decision-making.

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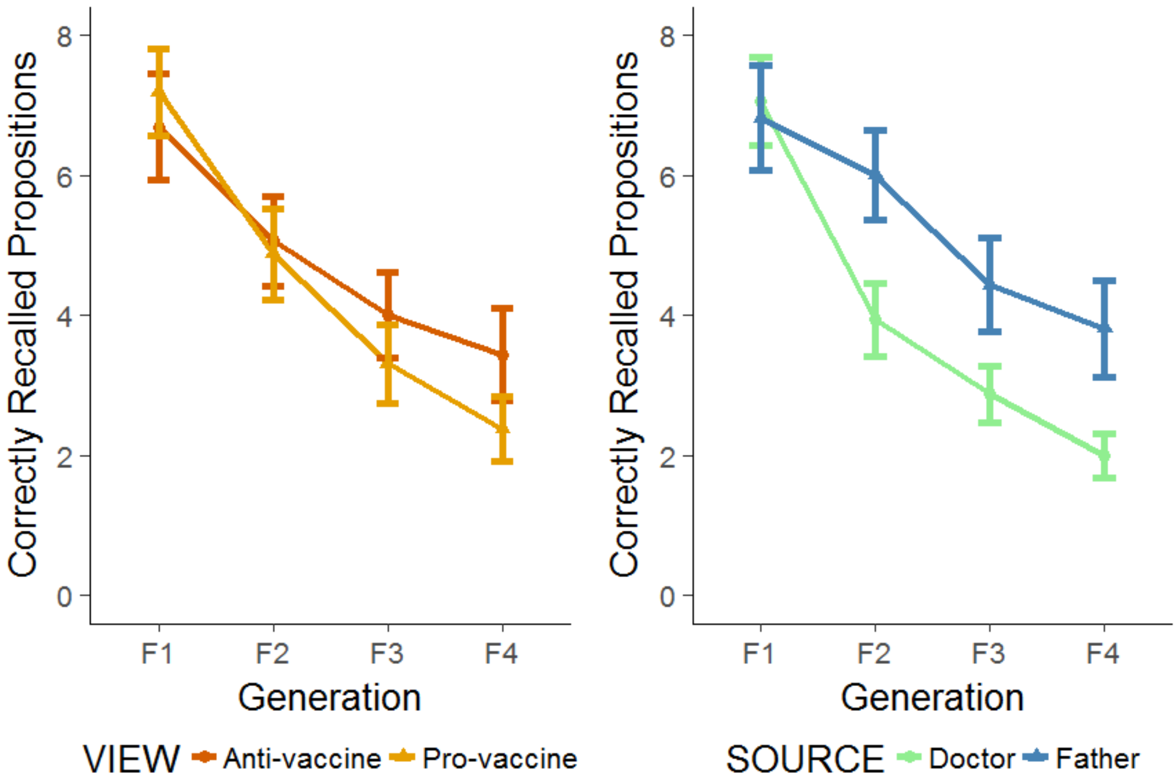

Figure 1. Raw means for the recall of information with 1.96 standard error bars plotted against generation. Left: Contrary to H1, the cumulative recall of the pro-vaccine and anti-vaccine views were similar. Right: In support of H2, the cumulative recall of the information provided by the parent was better transmitted than the information provided by the doctor.

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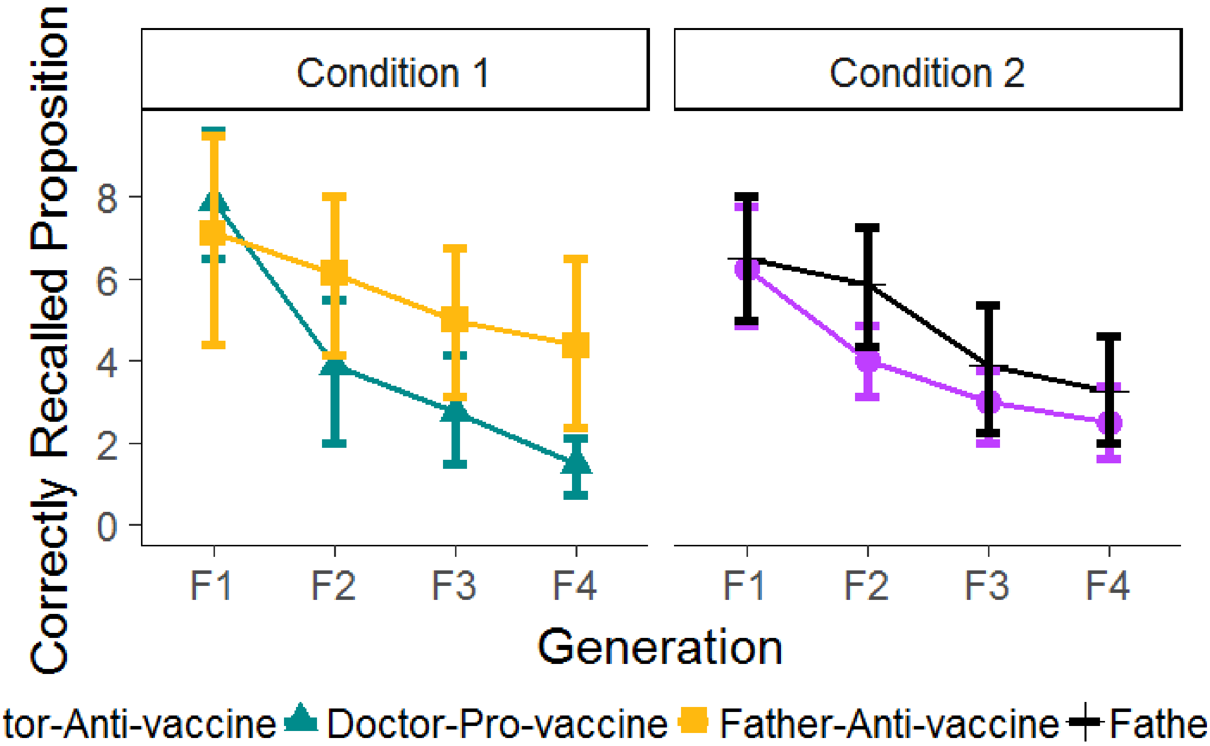

Figure 2. Raw means for the recall of information with 1.96 standard error bars plotted against generation. Left: Supporting H3, the anti-vaccination view of the parent was better transmitted than was the pro-vaccination view of the doctor (Condition 1). Right: Contrary to H3, the anti-vaccination view of the doctor was similarly transmitted to the pro-vaccination view of the parent (Condition 2).

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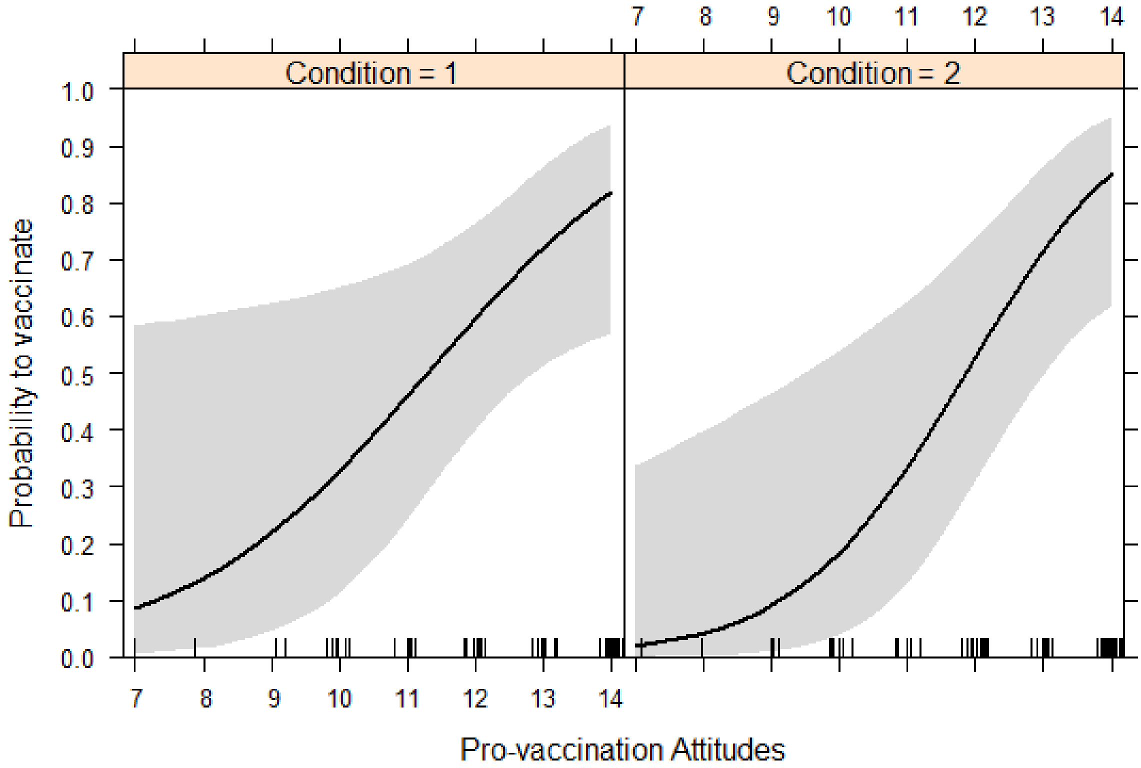

Figure 3. Visualization of the effects of a logistic regression predicting the probability to vaccinate using as predictors the interaction between Condition and Pro-Vaccination Attitudes (7 – neutral attitude to 14 – very positive attitude). The lines and the grey areas indicate the mean probability of deciding to vaccinate and its associated confidence interval for each level of pro-vaccination attitudes and the confidence interval respectively.